AMERICAN UNIVERSITY
WASHINGTON, DC

Department of Economics
Working Paper Series

The Economic Consequences of Dollar Appreciation for U.S. Manufacturing Investment: A Time-Series Analysis

by

Robert A. Blecker

No. 2006-07
Revised
August 2006

http://www.american.edu/academic.depts/cas/econ/workingpapers/workpap.htm

Forthcoming, *International Review of Applied Economics* (2007)

The Economic Consequences of Dollar Appreciation for US Manufacturing Investment: A Time-Series Analysis

By

ROBERT A. BLECKER
Professor of Economics
American University
4400 Massachusetts Ave., N.W.
Washington, DC 20016-8029 USA
E-mail: blecker@american.edu

Revised
August 2006

ABSTRACT:

This paper analyzes the effects of the real value of the dollar on investment in US domestic manufacturing using aggregate data for 1973-2004. Econometric estimation shows a negative effect that is much larger than has been found in any previous study. The exchange rate affects investment mainly, although not exclusively, through the channel of financial or liquidity constraints, rather than by affecting the desired stock of capital. Counterfactual simulations show that US manufacturing investment would have been 61% higher and the capital stock would have been 17% higher in 2004 if the dollar had not appreciated after 1995.

KEY WORDS: investment, manufacturing, exchange rate, US dollar, profits, US economy.

JEL CLASSIFICATION: E22, F31, L60, E25

The Economic Consequences of Dollar Appreciation for US Manufacturing Investment: A Time-Series Analysis

Introduction

The wide fluctuations in the real value of the dollar since the advent of floating exchange rates in 1973 have led to concern about the impact of the dollar's fluctuations on the tradable goods-producing sectors of the US economy, principally manufacturing. Given the enormous shrinkage of US manufacturing employment and the growing US trade imbalance (which consists mainly of a deficit in manufactures) since the dollar began appreciating in the late 1990s,[1] the impact of the exchange rate on capital formation in the domestic manufacturing sector is a matter of great policy significance. Although a few previous studies have investigated this issue, all of them were conducted before data from the post-1995 dollar appreciation were available. Moreover, these previous studies have found conflicting results, with some finding that dollar appreciation has had mostly negative effects on domestic investment and others finding mostly positive effects, and most studies finding small effects in either direction.

Moreover, previous studies have not sufficiently 'connected the dots' between the different effects that have been found in different branches of the existing literature, particularly in regard to the role of profits as an intermediary variable in how exchange rates affect investment. A large literature (e.g. Feinberg, 1986, 1989; Marston, 1990) confirms the existence of 'partial pass-through' of exchange rate changes, which implies that they affect firms' price-cost margins or 'mark-ups', and Clarida (1997) has found time-series evidence for a large and significant negative effect of the real value of the dollar on aggregate profits in US manufacturing. Many empirical studies have found significant effects of various measures of profits in investment functions, but these studies have generally ignored exchange rates, while the few studies that have included exchange rates in investment functions have generally omitted profits.

To this author's knowledge, none of the literature on investment functions to date has included both profit and exchange rate variables in the same model of investment; this suggests that previous studies of investment may have suffered from omitted variable bias. In addition, if investment depends on both profits and the exchange rate, and profits are an endogenous variable that also depends on the exchange rate, this raises obvious concerns about potential simultaneity bias or cross-equation correlation of the residuals in estimates of investment and profit functions. Our empirical results will show that simultaneity bias is not a significant problem, and that omitted variable bias is more pronounced in the models that have omitted exchange rates than in the ones that have included them.

Aside from these statistical concerns, there is also the substantive question of *how* exchange rates affect investment. Most previous studies have assumed that the exchange rate affects *expected* future profits—and therefore the desired capital stock—in a firm or industry located in a particular country by influencing the relative prices of domestic and foreign goods (as well as the cost of imported inputs). However, much theoretical reasoning and empirical evidence suggest that *actual* profitability can have an independent, positive effect on investment if the opportunity cost of internal funds is less than the cost of external funds (debt or equity), for example because asymmetric information between borrowers and lenders imposes financial constraints on firms. In other words, the level of realized profits (internal funds or cash flow) can impose 'liquidity constraints' that may reduce actual investment expenditures below planned or desired levels in the presence of capital market 'imperfections'. This suggests another channel for exchange rates to affect investment, insofar as currency appreciation may squeeze price-cost margins and decrease sales volumes, thereby reducing realized profits and tightening financial constraints. Therefore, this paper will estimate models that encompass both ‘direct’ effects of the exchange rate on investment via desired capital stocks and ‘indirect’ effects via actual profits.

This paper addresses these issues using aggregate time-series data for the manufacturing sector, which accounts for the vast majority of US merchandise trade.[2] Of course, the effects of the exchange rate on investment in other sectors of the economy—many of which are more consumers of imported inputs rather than internationally competing industries—may be quite different, as previous studies indicate. The previous literature also confirms that there are notable differences in these effects among different branches of manufacturing. Indeed, most of the existing literature has focused on *differences* in exchange rate effects on investment at the detailed industry level or in various industry groupings. This paper, in contrast, focuses on the *overall* impact of exchange rates on aggregate profits and investment in the US domestic manufacturing sector as a whole, and shows that some disaggregated approaches may have given a misleading impression of that overall impact.

The aggregate time-series analysis in this paper finds robust evidence for strongly negative effects of the real value of the dollar on total investment in US domestic manufacturing since 1973. These negative effects (elasticities) are much larger than have been found in any previous study, and have not diminished during the most recent decade of available data (1995-2004). It will be suggested below that some previous studies may have emphasized cross-sectional differences in industry responses (as compared with time-series, within-industry responses) in a way that was inadvertently biased toward finding positive overall effects of dollar appreciation. To fully resolve this issue, however, would require extending the present modeling framework to disaggregated panel data at the industry or firm level, which is beyond the scope of this paper and will have to be the subject of future research.

Literature Survey

Studies of Exchange Rate Effects on Investment

Although there is a huge empirical literature on investment functions, only a few studies have considered exchange rate effects on US investment.[3] To this author's knowledge, Worthington (1991) was the first to analyze exchange rate effects on investment in US manufacturing. She used a simple model of investment, in which the only other variable included besides the real exchange rate was an accelerator effect proxied by the ratio of actual-to-potential real gross national product (GNP). Using industry-level, annual panel data for 1963-1986, she found significant negative effects of the real value of the dollar on the investment rate (ratio of gross investment to capital stock). However, the exchange rate effects she found were relatively small; her coefficient estimate for all industries implied an average elasticity of –0.06. She also found considerable variation at the individual industry level, including larger negative effects in industries with higher import-sales ratios than in industries with lower import-sales ratios.

Goldberg (1993) investigated the effects of the real value of the dollar on investment at various levels of industrial aggregation and disaggregation, using quarterly US time-series for 1970:1-1989:4 and two sub-periods.[4] She found that there were no statistically significant effects of the real exchange rate on investment in any of the more aggregated industries (including all manufacturing) for the entire sample period, and many of the significant effects that were found (either in the split samples or for more disaggregated industries) were positive—especially in the second sub-period, 1979:3-1989:4. Goldberg attributed these positive effects to the increasing importance of imported inputs, which are cheapened by dollar appreciation.

Goldberg's failure to find more significant effects of the real exchange rate may have resulted in part from her use of quarterly data. Investment decisions are based on long-run expectations about the future returns to newly installed capital; actual investment expenditures lag behind planned investment decisions because of the time it takes for changes in observed economic conditions to affect firms' desired investment plans, and then to order and install new equipment or construct new facilities, as well as to arrange financing. Therefore, one would not necessarily expect to find significant effects of quarterly fluctuations in exchange rates on investment, either contemporaneously or with only short quarterly lags.[5]

Later, Campa & Goldberg (1995) found more significant effects of exchange rates on US investment using annual, industry-level panel data.[6] Their main innovation was to weight the real exchange rate by four measures of 'industry external exposure': (1) the export share; (2) the share of imported inputs; (3) the net difference between (1) and (2); and (4) a net measure in which the imported input share was adjusted for price-cost margins. As expected, the authors found larger and more significant negative effects when the exchange rate variable was interacted with measures (1), (3) and (4), and generally positive and significant effects when the exchange rate was interacted with (2). Because the share of imported inputs (2) was rising and the net measures (3) and (4) were falling in many industries during their sample period, Campa & Goldberg found that the negative effects of the value of the dollar on investment were diminishing over time or even turning positive in some sectors. They also found that the exchange rate had a greater impact on investment in more competitive industries, i.e. those with relatively low price-cost margins.

Campa & Goldberg (1999) extended their earlier work to a comparison of investment functions for panels of industry-level data from four countries (Canada, Japan, UK and US).[7] The results for the US mostly confirmed the authors' previous qualitative conclusions.[8] The new estimates suggested that dollar appreciation had an overall positive effect on domestic investment in US manufacturing industries; the elasticity ranged from an average of 0.1 in high mark-up industries to 0.2 in low mark-up industries. There was a wide range in the responses of investment to the exchange rate across individual industries, however, with some showing large negative responses and others showing large positive responses.

In spite of their emphasis on interacting exchange rates with measures of industry external exposure, however, Campa & Goldberg (1995, 1999) omitted one of the most important such measures: the share of imports of *finished* goods (as opposed to imported *inputs*) in total domestic demand.[9] The omission of import competition in domestic product markets seems likely to produce underestimates of the negative impact of the dollar's value on investment, especially in light of Worthington's finding that this impact was stronger in industries facing greater import competition. Campa & Goldberg's method of interacting trade weights (export and imported input shares) with exchange rate changes may also have had the unintended effect of overemphasizing cross-sectional differences in the trade weights (especially imported input shares) relative to time-series changes in the value of the dollar, particularly since the exchange rate was differenced but the weights were measured in levels.[10] Our estimates below show that the negative effects of the dollar are significant only when the exchange rate is measured in levels, not differences. Moreover, the rising shares of imported inputs may be at least partly endogenous responses to persistent dollar appreciation which has made such imports cheaper, as will be discussed further in the conclusions.

More General Literature on the Investment Function

Although there are only a few studies of exchange rate effects on investment, there is a vast literature on investment functions that has mostly ignored exchange rates or other international factors. Traditionally, investment is modeled as a process in which firms purchase new capital goods in order to achieve desired levels of their capital stocks. Much of the previous empirical literature has focused on the determinants of desired capital stocks, particularly on the relative importance of price variables (e.g. interest rates or the 'user cost of capital'[11]) versus quantity variables (e.g. utilization rates or growth rates, often referred to as 'accelerator effects'). Theoretical support for price effects has a long pedigree, but econometric results for whether these effects are large or significant are notoriously sensitive to model specification. According to the survey by Chirinko (1993), quantity variables have been the most robust explanatory factors in empirical investment models.[12] More recently, Chirinko *et al.* (1999) have found that the user cost of capital has a statistically significant but relatively small negative effect on investment in US firm-level data, with a central estimate of the user cost elasticity around –0.25.

Another branch of the investment function literature has emphasized the role of profit variables. Theoretical rationales for profit effects on investment fall into two distinct groups. First, in the context of imperfect capital markets, a firm's gross cash flow can be viewed as an indicator of its creditworthiness (ability to service debt) to potential lenders, and hence can determine whether it is credit-rationed or faces increasing borrowing costs. As a result, a firm may prefer to finance investment internally because external funds (bank loans, bond issues, or new shares of equity) would be more expensive. In this situation, a low level of cash flow may constrain a firm from making otherwise desired capital expenditures.[13] Second, from a Keynesian viewpoint, higher actual (net) profits may lead to increased investment because firms have myopic expectations about future profitability (see e.g. Robinson, 1962; Marglin, 1984). In this view, firms use actual net profits as an indicator of expected returns to new capital accumulation in the presence of fundamental uncertainty about future profits. Implicitly, the second view holds that actual realized profits do not merely impose liquidity constraints on borrowing firms, but also influence firms' desired capital stocks.

Numerous empirical studies have found significant positive effects of various measures of profits on business fixed investment, in a wide variety of models that control for various other determinants of investment. These studies include Abel & Blanchard (1986), Fazzari *et al*. (1988), Crotty & Goldstein (1992), Fazzari (1993), Bosworth (1993), Bhaskar & Glyn (1995), Chirinko & Schaller (1995), Worthington (1995), Gordon (1995, 1997), Chirinko *et al*. (1999) and Stockhammer (2004).[14] However, none of these studies has tested for exchange rate effects,[15] while none of the studies that have linked investment to exchange rates has included profit or cash flow variables. This is especially surprising because, as noted earlier, many studies—including Campa & Goldberg (1999) as well as Clarida (1997)—have found significant effects of exchange rates on profit (price-cost) margins or total realized profits.[16]

Previous studies of exchange rates and investment—especially Campa and Goldberg (1995, 1999), who modeled this formally—have tended to presume that the exchange rate affects investment only through its impact on the desired capital stock. This impact occurs because the exchange rate affects the expected future profitability of producing goods in a given industry in a given country. On the one hand, currency appreciation makes domestic products less competitive both in export markets and relative to imports, which tends to discourage investment in domestic industries.[17] On the other hand, currency appreciation lowers the cost of imported inputs (intermediate goods or raw materials), which tends to encourage investment in industries that rely heavily on such imports. The net balance of these two effects determines whether currency appreciation leads to increases or decreases in the desired capital stock and (with suitable lags) investment. We call this the 'direct' effect of the exchange rate on investment. However, this approach misses another channel through which the exchange rate can affect investment. Insofar as the exchange rate affects actual profits, then the exchange rate can either tighten or loosen financial (liquidity) constraints on investment spending. We call this the ‘indirect’ effect of the exchange rate on investment, which is in addition to any possible ‘direct’ effects on the desired capital stock.

Econometric Framework and Data Set

Econometric Specification

To summarize the above discussion and motivate the empirical analysis, a fairly general linear investment function for any given industry or aggregate sector can be written as an autoregressive distributed lag (ARDL) model with p lags on the lagged dependent variable and q lags on the independent variables (ARDL(p, q)):[18]

$$I_t / K_{t-1} = \beta_0 + \sum_{i=1}^{p} \beta_{1i} I_{t-i} / K_{t-i-1} + \sum_{i=0}^{q} \beta_{2i} \Delta Y_{t-i} / Y_{t-i-1} + \sum_{i=0}^{q} \beta_{3i} \Delta C_{t-i}^{K} + \sum_{i=0}^{q} \beta_{4i} E_{t-i} + \sum_{i=0}^{q} \beta_{5i} \Pi_{t-i} / P_{t-i-1}^{K} K_{t-i-1} + u_t \qquad (1)$$

where t indexes the time period (year), I is the real flow of investment spending, K is the end-of-period real capital stock, Y is real output, C^K is the cost of capital funds (either the real interest rate or user cost), E is the real exchange rate (real value of the home currency), Π is nominal profits (which could be either net profits or gross cash flow), P^K is the chain-type price index for the capital stock and u is the error term. Output is measured as a growth rate and the cost of capital is measured in difference form (either the change in the interest rate or the percentage change in the user cost), because the levels of these variables determine the level of the desired capital stock, but investment is the *change* in the capital stock; for the moment, we leave open the question of whether the exchange rate and profit rate should be measured in levels or differences as theory is less clear on these variables.[19] The output growth rate ('accelerator') and profit variables are generally expected to have positive effects, while the cost of capital is expected to have a negative effect, and the sign of the direct exchange rate effect is theoretically ambiguous because of the different impact on competition with foreign producers and costs of imported inputs.

In many traditional studies of investment, especially those using firm-level panel data, the lagged dependent variable is not used ($p = 0$), and large numbers of lags q are allowed on the independent variables. In order to preserve degrees of freedom with our relatively small, aggregate time-series data set (with only 32 annual observations), we restrict the lags to $p = q = 1$ and use the coefficient on the one-year lagged dependent variable to capture the persistent effects of shocks to the independent variables from previous years.[20] Under this restriction, the 'long-run' coefficients for the independent variables (m = 2, 3, 4, 5) can be measured by

$$\beta_{mLR} = \frac{\beta_{m0} + \beta_{m1}}{1 - \beta_{11}}. \qquad (2)$$

Conceptually, a lagged dependent variable makes sense in this context because of the slow adjustment of actual investment expenditures to desired or planned changes in capital stocks, as well as the possibly persistent effects of financial constraints. Statistically, the use of the lagged dependent variable avoids serial correlation of the residuals in the estimated investment equations.

In addition, as discussed earlier, profits are likely to be a function of the real exchange rate in an open economy. Thus, current $\Pi_t / P_{t-1}^K K_{t-1}$ in equation (1) is an endogenous variable. Again using an ARDL(p, q) specification for convenience, we specify the profit function as

$$\Pi_t / P_{t-1}^K K_{t-1} = \alpha_0 + \sum_{j=1}^{p} \alpha_{1j} \Pi_{t-j} / P_{t-j-1}^K K_{t-j-1} + \sum_{j=0}^{q} \alpha_{2j} E_{t-j} + \sum_{j=0}^{q} \alpha_{3j} X_{1,t-j} + \cdots + \sum_{j=0}^{q} \alpha_{n+2,j} X_{n,t-j} + v_t \qquad (3)$$

where X_1 to X_n are n other exogenous variables (besides the exchange rate) that affect profits and v_t is the error term. In principle, the effects of E may be either positive or negative depending on the degree to which a given industry or sector competes with foreign products or relies on imported inputs. Clarida's (1997) results strongly suggest a negative effect of E for the US manufacturing sector as a whole, even though there may be exceptions in other sectors or at a more disaggregated level. Since there is less theory to rely on in specifying the profit equation (3) than the investment equation (1), the lagged dependent variable in (3) is useful for capturing the effects of possible omitted explanatory variables (again we restrict the lags to $p = q = 1$).

Although equations (1) and (3) comprise a system of simultaneous equations, they constitute a special case known as a 'triangular' or 'recursive' system (see Greene, 1997, pp. 715-16, 732, 736-37). Because $\Pi_t / P^K_{t-1} K_{t-1}$ does not depend on I_t / K_{t-1}, equation (3) can be estimated consistently and efficiently by ordinary least squares (OLS) and there is no simultaneity bias in OLS estimation of (1), provided that the errors u_t and v_t are uncorrelated (so that $\Pi_t / P^K_{t-1} K_{t-1}$ is not correlated with u_t). However, if u_t and v_t are correlated, then $\Pi_t / P^K_{t-1} K_{t-1}$ is also correlated with u_t, and OLS estimates of (1) would be biased and inconsistent; it then becomes necessary to use a systems method such as three-stage least squares (3SLS), which combines instrumental variables with seemingly unrelated regression (SUR), to obtain consistent and unbiased estimates of (1) and (3). We will test for whether there is a significant correlation between the estimated residuals $\hat{u}_t$ and $\hat{v}_t$ in our econometric analysis below.

Data Set and Unit Root Tests

An annual frequency is typically used in econometric studies of investment functions because fixed investment is a long-run oriented business decision, and therefore annual data are likely to better reflect the determinants of investment than higher-frequency data (as discussed earlier).[21] The sample period was limited to 1973-2004 (or shorter periods as necessitated by lags) as a result of data limitations. The Federal Reserve (Fed)'s comprehensive 'broad' index of the real value of the dollar begins in 1973, and there is no comparable index earlier. Besides, the openness of the US economy to foreign trade and capital flows has increased dramatically since the early 1970s, and this fact coupled with the switch from adjustable pegs to floating rates suggests that the exchange rate was likely to have played a less significant role in US business decisions in earlier years. At the other end, 2004 was the last year for which manufacturing sector-level data on investment and capital stocks had been released at the time of this writing.

The 'investment rate' I_t / K_{t-1} in the manufacturing sector is measured with both the numerator and denominator in 'real' terms.[22] For profits (Π), because the previous literature has used different measures and also as a sensitivity test, we use two alternative measures: net corporate profits and gross corporate cash flow (the sum of undistributed profits plus depreciation allowances) in the manufacturing sector. Cash flow is more commonly used to represent the existence of financial constraints, but net profit has also proven significant in some previous studies. Each of these profit variables is measured in current dollars and normalized by the nominal capital stock (at current or replacement cost) at the end of the previous period; these two alternative measures of $\Pi_t / P_{t-1}^K K_{t-1}$ are referred to as the 'net profit rate' and 'cash flow ratio'.

The construction of consistent time series for the industry-level variables for the period 1973-2004 is complicated by the switch from the old Standard Industrial Classification (SIC) to the new North American Industrial Classification System (NAICS), which changed the definition of what is included in 'manufacturing'. Consistent historical data for investment spending, capital stocks and depreciation by industry have recently become available on a NAICS basis, but industry-level profit data are available on a NAICS basis only from 1998 forward. This necessitated 'splicing' the series for the net profit rate and cash flow ratio in 1999 (using the overlapping data for 1998-2000).[23] Although the NAICS manufacturing sector is defined more narrowly than the corresponding SIC sector, the former accounted for about 90% of the net income produced in the latter during the three years of overlapping data. Sensitivity tests show that estimates of equation (1) using the old SIC-based investment and capital stock data (which ended in 2001) yield quantitatively similar coefficients compared with the estimates using the NAICS series, especially for the real dollar index.[24] Thus, our main results are not sensitive to either the switch to NAICS data or the splicing of the profit variables.

The other variables are measured by broader aggregates that are likely to be exogenous to the manufacturing sector. For the accelerator variable ($\Delta Y_t / Y_{t-1}$), we used the growth rate of real gross domestic product (GDP); this measure is useful for comparability with the previous studies of exchange rates and investment, which generally used a GDP- (or GNP-) based measure of accelerator effects. The exchange rate (*E*) is measured by the Fed's broad index of the real value of the US dollar ('real dollar index'), which is price-adjusted and trade-weighted with almost all US trading partners (both industrialized and developing countries).

For the cost of capital funds, we use two alternative measures that reflect differences in the investment literatures cited earlier, and as a sensitivity test. The first measure is the real interest rate (*r*), defined as Moody's Aaa corporate bond rate minus the percentage rate of change in the GDP chain-type price index ('real Aaa interest rate'). The second measure is the 'user cost of capital' (*UC*), i.e. the rental cost of a unit of capital measured by the sum of the financial cost of capital and the depreciation rate adjusted by the relative price of investment goods to total output. The equation we use is a simplified version of the one found in Chirinko *et al.* (1999):[25]

$$UC_t = \left(P_t^I / P_t^Y\right) \cdot \left[0.67\left(div_t + 2.4\right) + 0.33 r_t + \delta_t\right] \quad (4)$$

where P_t^I is the chain-type price index for fixed nonresidential investment, P_t^Y is the chain-type price index for GDP, div_t is the dividend-price ratio for the Standard & Poor's Composite Stock Index (to which Chirinko *et al.* add 2.4% as an expected long-run growth rate to approximate the cost of equity), r_t is the real interest rate as defined above (to represent the cost of debt) and δ_t is the depreciation rate of the capital stock (depreciation as a percentage of the lagged net capital stock). The weights 0.67 and 0.33 are used to roughly approximate the 'typical' proportions of own funds and borrowed funds used to finance investment spending by US corporations.

Before estimating equations (1) and (3), we tested for stationarity of the included variables.[26] Summarizing briefly, two alternative tests show that the GDP growth rate, real dollar index and percentage change in the user cost of capital are stationary (i.e. do not have unit roots). Results for the investment rate, net profit rate, cash flow ratio and real interest rate were sensitive to the type of unit root test used and the specification of the test (e.g. whether a trend was included and whether the variable was differenced). All the variables used in the regressions were found to be stationary at the 5% level using Kwiatkowski *et al.* (1992) tests,[27] but the results were mixed using more conventional augmented Dickey-Fuller (ADF) tests. Given the lack of robust evidence that any of the variables have unit roots, and given the strong theoretical reasons to specify the investment equation in the form of equation (1), we proceed on the assumption that all the variables in this equation are stationary. However, as a sensitivity test, we will estimate the profit equation (3) in both levels and first differences—partly because the net profit rate variable shows the most evidence of a unit root in levels but is clearly stationary in differences, and partly because the cash flow variable is significant in the investment equation (when the exchange rate is also included) only when measured in differences.

Econometric Estimates of Investment and Profit Functions

This section reports the results of estimating equation (1) for investment and equation (3) for profits, using the two alternative measures of profits (net profit rate and cash flow ratio) and a variety of other alternative specifications (sensitivity tests) as described below. All of these equations are estimated using OLS because of the recursive nature of the model. For each equation and specification, we started with a general ARDL(1,1) model. Lags longer than one year were not used because of the short sample size, and because longer lags were generally insignificant when the lagged dependent variable was included. Although formal general-to-specific procedures (e.g. Hendry & Krolzig, 2002) were not used, a more parsimonious lag structure was arrived at by eliminating redundant variables (current or lagged) through the use of redundant variable likelihood ratio (LR) tests (with a 10% significance level threshold),[28] except that, in certain equations, some variables were deliberately included or excluded either for comparison with previous studies or to test a particular specification. In all models, tests for Gaussian randomness of the residuals were conducted to ensure that the resulting models yield statistically valid hypothesis tests. Newey & West (1987) corrected covariances were used in calculating all standard errors. Dummy variables for outlier observations were added to those equations in which: (1) the residuals for one or more years were unusually large (defined as greater than ±2 standard deviations); and (3) adding the dummies helped to correct for non-normally distributed or serially correlated residuals. This proved to be necessary only in the profit equations. The section concludes with tests for cross-equation correlation of the OLS residuals, the insignificance of which validates the use of OLS.

Investment Equations

The first set of estimates is shown in Table 1. Equation (1.1) is a ‘baseline’ model that utilizes a specification similar to earlier studies of exchange rate effects, in which profit variables are omitted. No lags were eliminated by the redundant variable LR tests, so the table reports the sums of the coefficients for the current value and one-year lag of each variable and the corresponding standard errors (except the lagged dependent variable). The residual diagnostic tests (Breusch-Godfrey for serial correlation[29] and Jarque-Bera for normality) and the RESET misspecification test do not indicate any problems. The accelerator effect (GDP growth rate) and real interest rate (in first differences)[30] are both significant at the 1% level and have the expected signs (positive and negative, respectively). The real dollar index is negative and significant at the 1% level, with a coefficient of –0.042. The fact that the dollar index is significant in levels (and was not significant when measured in differences) suggests that its effects are related to short-run financial constraints, rather than long-run desired capital stocks.

<Table 1 here>

Omitted variable LR tests (not shown in Table 1) imply that the net profit rate should not be included in equation (1.1) either in levels or in first differences, but the cash flow ratio should be included (with a *p*-value of 0.081 in levels and 0.019 in first differences). However, when these variables are measured in levels, both the net profit rate and cash flow ratio have the ‘wrong’ signs (negative) and are insignificant (according to *t*-tests) when included in equations (1.2) and (1.3), respectively (see Table 1).[31] The coefficients on the other variables are quantitatively similar with either of these profit variables included, which is not surprising given that the latter are insignificant. However, the anomalous results for the two alternative profit variables could be spurious, if these variables truly have unit roots in levels while the other variables are stationary.

Given the ambiguous evidence about the stationarity of both profit variables measured in levels,[32] and since there are not strong theoretical reasons to insist that they be measured in levels, we therefore re-estimate the investment functions with either profit variable measured in first differences (which are definitely stationary, according to all tests).

The results reported in columns (1.4) and (1.5) of Table 1 show that the first differences of the net profit rate and cash flow ratio both have positive coefficients (sums for zero and one lag). However, only the cash flow ratio is significant at the 10% level, and this hypothesis test may not be valid since the Breusch-Godfrey test indicates significant serial correlation at the 5% level (*p*-value of 0.040) using two lags of the residuals. Otherwise, the coefficients on the other variables remain similar in magnitude to the other equations shown in Table 1, although the negative coefficient on the real dollar index is slightly smaller (in absolute value) in equations (1.4) and (1.5), indicating that there may be a small omitted variable bias in the equations that do not include the differenced profit variables. However, all the equations in Table 1 use the change in the real interest rate on bonds, rather than the user cost of capital which also includes the costs of equity and depreciation and which controls for the relative price of capital goods.

The first two columns in Table 2 show the results of baseline regressions using more conventional investment functions, which omit exchange rates and include the percentage change in the user cost of capital (instead of the differenced real interest rate) along with one of the two alternative profit variables (in levels). In these two equations, redundant variable LR tests eliminated either the current or lagged value of every right-hand side variable except the GDP growth rate, for which we give the sum of the coefficients on zero and one lag. As before, the lagged dependent variable is positive and strongly significant (1% level). The user cost of capital has a negative sign in both equations and is significant at the 5% level using the net profit rate and the 10% level using the cash flow ratio. The profit variables have coefficients that are positive and significant at the 5% level in both equations (2.1) and (2.2). Equation (2.1) satisfies the standard diagnostic tests, but equation (2.2) exhibits serially correlated residuals according to the Breusch-Godfrey LM tests. Also, omitted variable LR tests (shown in Table 2) imply that the lagged real dollar index should be included in either equation (2.1) or (2.2). This suggests that the estimated coefficients in equations (2.1) and (2.2) may suffer from omitted variable bias, and the omitted variable could be a source of the serially correlated residuals in the latter equation.

<Table 2 here>

The last two columns in Table 2 show estimates of investment functions that include the one-year lagged real dollar index along with each measure of profits (in levels).[33] The inclusion of the lagged dollar index makes the accelerator (GDP growth rate) coefficient larger, but the coefficient on the user cost variable is still negative and significant with a similar magnitude to what was found with the dollar index omitted. The coefficient on the real dollar index is around the high end of the estimates in Table 1, with a magnitude of about –0.05, and is significant at the 1% level in both equations (2.3) and (2.4). However, the profit variables become insignificant in both of these equations, suggesting that profits are correlated with the lagged dollar value, and supporting the existence of omitted variable bias if the latter variable is excluded. This suggests either that previously estimated profit effects may have picked up what are really exchange rate effects in US manufacturing, or else that the exchange rate is the main driver of profits in US manufacturing and hence including the exchange rate 'knocks out' the profit variable. This result—combined with the fact that the exchange rate is significant in levels and not in differences—also supports the view that the exchange rate affects investment through financial constraints, rather than through the desired capital stock.

However, as noted earlier, the result that the profit variables are insignificant when the exchange rate is included could be spurious if the profit variables have unit roots, and Keynesian theories of investment under uncertainty imply that realized profits can affect desired capital stocks. Therefore, we again try the sensitivity test of re-estimating the investment functions with the profit variables measured in first differences, in the more conventional specification using the percentage change in the user cost of capital. These estimates are shown in Table 3 for the two alternative measures of profits. Equations (3.1) and (3.2) are baseline regressions in which the exchange rate is omitted.[34] The lagged, differenced net profit rate is significant at the 1% level in equation (3.1), although rather anomalously the accelerator effect is insignificant in this equation. The lagged, differenced cash flow ratio is significant at the 10% level in equation (3.2), while the accelerator effect is significant at the 1% level. In both of these equations, the lagged percentage change in the user cost is negative and significant at the 5% level.

<Table 3 here>

In both equations (3.1) and (3.2), omitted variable LR tests indicate that the lagged real dollar index should be included. When the lagged real dollar index is included in equations (3.3) and (3.4) in Table 3, most of the results are very similar using either the net profit rate or cash flow ratio: the accelerator (GDP growth) effect, (lagged) change in the user cost and (lagged) real dollar index are all significant at the 1% level, with similar coefficients in both equations. However, the (lagged, differenced) cash flow ratio is significant at the 1% level in equation (3.4), while the (lagged, differenced) net profit rate is insignificant at the 10% level in equation (3.3). These results may suggest that cash flow is a better measure of financial/liquidity constraints than net profits, but they could also suggest that cash flow affects the desired capital stock since cash flow is significant only in difference form when the exchange rate is also included.

The user cost elasticities of the desired capital stock implied by our estimated coefficients in Tables 2 and 3 range from about –0.3 to –0.6, with an average of –0.46 in all eight equations in which this variable is included and –0.39 in the four equations that also include the real dollar index.[35] These estimates are slightly higher than the central estimate of –0.25 in Chirinko *et al*. (1999), but still notably below unity (in absolute value). Most importantly for purposes of this paper, the coefficient on the real dollar index is uniformly negative and significant at the 1% level in all specifications in Tables 1-3, with a range of –0.03 to –0.05 and a central value of about –0.04.[36] This result is robust regardless of whether capital costs are measured by the real interest rate or user cost, whether profitability is included in the model or not, whether (if it is included) profitability is measured by net profits or cash flow and whether either profit variable is expressed in levels or differences.

Profit Equations

Next, to test for indirect effects of the exchange rate on investment via profits, we need to estimate equation (3), which requires the specification of the control variables X_{1t} to X_{nt}. Unfortunately, there is less theory to guide us on the aggregate profit function, and there are less relevant studies in the literature. Many of the variables that are commonly used in micro-level panel models to explain cross-industry or cross-firm variation in profitability (e.g. measures of industry concentration) are not very useful in aggregate time series. Some variables that might seem relevant, such as a measure of real energy costs (to represent 'supply shocks'), yielded unstable or anomalous results when included in the regression models, and hence were not used.[37] Since our main interest is in exchange rate effects, it will suffice for present purposes to construct a model that controls for enough other factors to yield reasonably reliable estimates of the exchange rate coefficients α_{2j} in (3).

Table 4 shows the models that were estimated for our two alternative measures of profits. Because of the uncertainty about whether profit variables are stationary in levels and whether they should be measured in levels or differences in the investment function, we estimate the profit functions in both levels and first differences. The sample periods for the equations in differences start in 1975 because of the need for an extra lag of the real dollar index. As before, insignificant variables (or lags) were eliminated using redundant variable LR tests. Because both profit variables exhibit a downward trend (and there is evidence from the unit root tests that they may be trend stationary), we include a time trend in both of the equations in levels. The other variables included are the lagged dependent variable, GDP growth rate,[38] and real dollar index. In both of the equations in first differences, the constant represents the time trend, and the lagged dependent variable was redundant and therefore omitted.

<Table 4 here>

Equation (4.1) in Table 4 shows the results for the net profit rate with the variables measured in levels. All variables are significant at the 1% level except the time trend, which is significant at the 5% level. As expected, the lagged dependent variable and GDP growth rate both have positive coefficients, while the real dollar index and time trend have negative coefficients. The diagnostic tests indicate no problems with the residuals or equation specification, although this requires three outlier dummies for 1975, 1986 and 2001. Equation (4.2) shows the corresponding specification in which all variables are first differenced. The positive effect of GDP growth and the negative effect of the real dollar index are both significant at the 1% level. The constant in equation (4.2) is negative but insignificant, indicating that there is not a significant downward trend in the net profit rate after controlling for the other variables. Again, the diagnostic tests indicate no problems (using an outlier dummy for 2001).

Equation (4.3) in Table 4 show the equation for the cash flow ratio in levels. The lagged dependent variable is not significant according to a *t*-test, even though it is not redundant at the 10% level according to an LR test and was therefore included. Otherwise, the results are similar to those for the net profit rate in equation (4.1), except that in the cash flow equation (4.3) current and lagged GDP growth were both significant, the negative time trend is somewhat stronger (significant at the 1% level), and the real dollar index has a slightly weaker negative effect (significant at the 5% level). Using an outlier dummy for 1974, the diagnostic tests indicate no problems.

Finally, equation (4.4) in Table 4 reports the results for the cash flow ratio in first differences. The (differenced) GDP growth rate is positive and significant at the 1% level, while the (differenced) real dollar index is negative and significant at the 5% level. The constant is positive but insignificant. Although the diagnostic tests indicate no problems with the residuals, the Ramsey RESET statistic for squared fitted values is significant at the 5% level, indicating possible misspecification of the equation or an omitted variable (even with outlier dummies for four years—1975, 1986, 1989 and 2001). Although this equation must therefore be interpreted cautiously, a significant negative effect of the real value of the dollar on aggregate profits is found using two alternative measures of profits, each measured either in levels or differences.

Testing for Consistency of the OLS Estimates

To confirm that the above OLS estimates are consistent and unbiased, we ran Breusch & Pagan (1980) Lagrange Multiplier (LM) tests for correlation of the residuals in the investment and profit equations. The Breusch-Pagan LM test statistic is

$$\lambda = n\sum_{i=2}^{m}\sum_{j=1}^{i-1}\rho_{ij}^2 ,$$

where n is the number of observations, m is the number of equations, ρ_{ij} is the correlation coefficient between the residuals of the i^{th} and j^{th} equations and (under the null hypothesis of no cross-equation correlation) $\lambda \sim \chi^2[0.5m(m-1)]$. With two equations ($m = 2$), this statistic reduces to $\lambda = n\rho^2$, where ρ is the correlation of the residuals from the two equations, and $\lambda \sim \chi^2(1)$. Using the four investment equations from Tables 2 and 3 with the real dollar index included, paired with the corresponding profit equations (either net profit rate or cash flow ratio, in levels or differences) from Table 4, the results (shown in Table 5) indicate that the null hypothesis of no cross-equation residual correlation cannot be rejected.[39]

<Table 5 here>

Elasticities, Simulations and Sensitivity Tests

Long-run Coefficients, Elasticity Estimates and Simulated Effects of Dollar Appreciation

In this section, we assess the implications of our results for the quantitative impact of the dollar's exchange rate in determining US manufacturing investment. Starting with the direct effects of the real dollar index in the estimated investment functions, the short-run coefficients on this variable from Tables 1-3 range from –0.032 to –0.049. Applying equation (2), the corresponding long-run coefficients range from –0.17 to –0.26. These coefficients (both short-run and long-run) are generally larger in the models that include the user cost of capital (Tables 2 and 3) than in the ones that include the real interest rate (Table 1). The long-run coefficients are large multiples of the short-run coefficients because of the high coefficients on the lagged dependent variable in most of the estimated investment functions. Evaluated at the sample means for the investment rate and real dollar index, these coefficients in turn imply short-run elasticities that range from –0.42 to –0.52 and long-run elasticities that range from –1.8 to –2.8 (again, the higher ends of these ranges correspond to the specifications with the user cost variable).

These are much larger negative elasticities than have been found in any of the previous literature, although they go in the same direction as the original findings of Worthington (1991) and the opposite direction from the later results of Campa & Goldberg (1999). Although the long-run elasticities may seem relatively high, they apply only if a shock to the real exchange rate persists long enough for the dynamic short-run adjustments to be completed so that the investment rate reaches its new equilibrium level. In reality, the exchange rate does not usually change once and for all to a new level, but rather fluctuates up and down over time, and therefore the investment rate may not reach its 'long-run' equilibrium before a new disturbance to the exchange rate moves investment again either further in the same direction or back the other way.

To get a better sense of how important fluctuations in the dollar have been for actual investment in US manufacturing in recent years, we consider the impact of the rise in the dollar's value after its trough in 1995. The real dollar index rose from 86.9 in 1995 to 111.2 in 2002, before falling to 99.8 in 2004 (representing an increase of 28% in 1995-2002 followed by a decrease of 10% in 2002-2004, for a net increase of 15% from 1995 to 2004). To gauge the effect of this behaviour of the dollar on investment, we simulate a counterfactual scenario in which the dollar remained fixed at its 1995 real value from 1996-2004 and compare the results of this scenario with a baseline simulation in which the dollar is assumed to have followed its actual trajectory after 1995. For this purpose, we use our 'best fit' investment model, which is equation (3.4) in Table 3 (the investment equation with the highest adjusted R^2). Because the model includes a lagged dependent variable, we run dynamic simulations in which this variable adjusts endogenously over time. Also, since the lagged change in the cash flow ratio is significant in this equation and the cash flow ratio is an endogenous variable, we simultaneously simulate equation (4.4) from Table 4 for the cash flow ratio in first differences, and we allow the simulated changes in cash flow to affect investment during the simulation period (1996-2004).[40]

In addition to these two stochastic equations for the investment rate and cash flow ratio, the model simulations require the following three identities to keep track of the capital stock and the levels of investment and cash flow over time:

$$K_t = (1-\delta_t)K_{t-1} + I_t \tag{5}$$

$$I_t = (I_t / K_{t-1})K_{t-1} \tag{6}$$

$$CF_t = (CF_t / P^K_{t-1}K_{t-1})P^K_{t-1}K_{t-1} \tag{7}$$

where I_t / K_{t-1} is the investment rate, CF_t is the level of the cash flow (which substitutes for Π in equations 1 and 3) and $CF_t / P^K_{t-1}K_{t-1}$ is the cash flow ratio. Thus, the model uses five equations to simulate the evolution of five endogenous variables: K_t, I_t, CF_t, I_t / K_{t-1} and $CF_t / P^K_{t-1}K_{t-1}$.

According to the counterfactual simulations, if the dollar had stayed constant at its 1995 level through 2004, US manufacturing investment would have been 12.8% of the lagged capital stock in the latter year, compared with 9.0% in the model baseline simulation, representing an increase of 42.9% in the investment rate in the latter year. The implied trajectory of real investment spending is shown in Figure 1. By 2004, real investment (measured at chained 2000 prices) would have been \$96.9 billion higher in the scenario with a constant dollar, representing a 61.3% increase over the baseline 2004 investment forecast of \$157.9 billion.[41] In addition, these simulations show that the real capital stock of the US manufacturing sector would have continued to grow rapidly in the early 2000s, rather than shrinking after 2001 as it actually did, had the dollar not remained persistently above its 1995 level. In our simulations, the real capital stock of the US manufacturing sector would have been 17.3% higher at yearend 2004 if the dollar had stayed at its 1995 real value, holding other factors constant.[42]

<Fig. 1 here>

Additional Sensitivity Tests

Since we have discussed several sensitivity tests already, this subsection will discuss just two more, results for which are available on request. First, we tested for how the results in this paper are affected by the inclusion of data for the most recent period of dollar appreciation since 1995. Regressions analogous to those in Tables 1-3 with samples that end in 1995, or any year between 1995 and 2003, yield coefficients on the lagged real dollar index that are uniformly negative and significant, and similar in magnitude to the coefficients found with the sample ending in 2004. Thus, the finding of a negative effect of dollar appreciation on investment in US manufacturing does not result from the use of data for the years after 1995. There is also no evidence that the negative effect of the value of the dollar diminished after 1995, in spite of the increasing reliance on imported inputs noted by Campa & Goldberg (1995, 1999).

Second, measuring the investment rate by the ratio of real investment spending to the lagged real capital stock, while theoretically correct, could result in measurement error if the procedures used to calculate these ‘real’ magnitudes are flawed. In particular, the falling prices of certain capital goods (especially computers) in recent years may exaggerate the real quantity of investment relative to the pre-existing capital stock. As an alternative, therefore, we ran regressions similar to those in Tables 1-3 using the investment rate with the numerator and denominator both measured at current cost, i.e. historical cost investment divided by the lagged value of the capital stock at replacement cost. For the most part, the results were qualitatively similar to those reported in Tables 1-3. Especially, the coefficients on the (lagged) real dollar index were negative and significant in all specifications using the current investment rate. However, the net profit rate and cash flow ratio generally remained positive and significant in levels when the real dollar index was included in the models using the current cost investment rate.[43] This could be because those profit variables are better at explaining nominal investment spending rather than the real quantity of capital goods, or it could be a spurious correlation due to common inflationary shocks affecting the nominal values of both profits and capital goods.

Conclusions and Implications

This paper has found robust evidence for a significant negative effect of real dollar appreciation on aggregate investment in US domestic manufacturing. This qualitative finding is not sensitive to a variety of alternative specifications, including two different measures of the cost of capital funds, two different measures of profits, estimation by OLS versus 3SLS, different ending dates for the sample period, and even using the ratio of nominal (current cost) investment to capital instead of the ratio of the real magnitudes as the dependent variable. The elasticity of investment with respect to the real dollar index is found to be much larger (i.e. more negative) in this study than in any previous study.

In addition, the results have important implications for the *channels* through which the exchange rate influences investment. Most previous studies have modeled the exchange rate as affecting investment only through the desired capital stock, and have ignored the alternative channel of financial or liquidity constraints. Our findings that the standard proxies for financial/liquidity constraints (net profits or cash flow measured in levels) become insignificant when the exchange rate is included in the investment function, and that these variables are significantly affected by the exchange rate, suggest that the dollar affects US manufacturing investment mainly through the channel of financial constraints, not through the desired capital stock. The finding that the real dollar index is significant in levels, not in differences, also supports the view that its effects are primarily short-term rather than long-term (similar to, or operating through, liquidity constraints). Nevertheless, there is some indication that the exchange rate may also affect the desired capital stock in the investment equations with the cash flow ratio measured in first differences, in which lags of both the real dollar index and the differenced cash flow ratio are significant. This suggests that the exchange rate may have additional effects via the desired capital stock, beyond those that are transmitted through cash flow and financial constraints.

Thus, in spite of the US manufacturing sector's increasing reliance on imported inputs in recent years, there is still a large negative overall effect of the dollar's value on investment in this sector that has not diminished to date. The results in this paper clearly imply that a lower value of the dollar would still be beneficial on average for most of the nation's tradable goods industries. However, the simulations which show that the increased value of the dollar since 1995 has significantly depressed the level of the capital stock in US manufacturing imply that it will be difficult for the US economy to adjust to a lower trade deficit even if the dollar falls further in the near future, because of the systematic disinvestment in the production capacity of this sector during the prolonged period of dollar overvaluation since the late 1990s. Under present conditions, the US economy might require a prolonged period of a low dollar for firms to be induced to re-invest sufficiently in manufacturing capacity to reverse the large trade imbalance.

Finally, it remains necessary to reconcile the results obtained in the time-series analysis in this paper with the very different results of Campa & Goldberg (1995, 1999), who found either less strongly negative effects or even positive effects of the dollar's value on investment for most manufacturing sectors using industry-level panel data. Earlier, we suggested some reasons why Campa & Goldberg's methodology might have been biased toward finding less negative (or more positive) effects of the value of the dollar on investment. Future research using panel data is needed to test the sensitivity of Campa & Goldberg's results to various aspects of their specification. However, accepting Campa & Goldberg's results as valid, we may speculate that their findings at a more disaggregated level could reflect the *evolution* of the US industrial structure in response to repeated periods of dollar overvaluation (i.e. the early 1980s and late 1990s-early 2000s). During such periods, industries that primarily export or compete with imports, but which don't rely heavily on imported inputs, would be expected to shrink (and to invest less), while the industries that have survived (and which have invested more) are precisely those that have adapted by outsourcing more inputs from abroad. As a result, the negative effect of dollar appreciation on *aggregate* manufacturing investment that we have found here could be consistent with increasingly positive effects in the surviving industries.

Acknowledgments

The author would like to thank Bob Chirinko, Steve Fazzari, Ray Mataloni, Bill Noellert, Arslan Razmi, Rob Scott and Christian Weller, as well as participants in the 2004 Post Keynesian Conference at the University of Missouri, Kansas City, for comments on earlier versions. Amos Golan and Maria Heracleous provided econometric advice and two anonymous referees made exceptionally helpful suggestions. The usual disclaimers apply.

Notes

[1] US manufacturing employment fell by 3.3 million jobs, from 17.6 million in 1998 to 14.2 million in 2005 (US Congress, 2006, p. 14). As of 2004, the US trade deficit for goods had reached $650.9 billion (on a Census basis), of which $550.8 or 84.6% was accounted for by manufactures (US Census Bureau, 2005, Part B, Exhibit 14).

[2] Manufactures represented 85.6% of US 'domestic exports' (excluding re-exports) and 79.9% of US imports of goods in 2004 (US Census Bureau, 2005, Part B, Exhibit 14).

[3] Unless otherwise stated, 'exchange rate' in this paper always means the trade-weighted, price-adjusted, real value of the US dollar.

[4] Goldberg (1993) and Campa and Goldberg (1995) included both the level and volatility of the real exchange rate in their models; since the estimated effects of volatility were generally small or insignificant, we restrict our discussion here to the results for the level.

[5] Goldberg (1993, pp. 579-580) stated that she used lags, but did not report exact lag lengths.

[6] The authors converted their data to growth factors (ratios of current/lagged values) for stationarity reasons, and used lagged exchange rates to avoid endogeneity problems. They also controlled for accelerator effects and real interest rates.

[7] Campa & Goldberg (1999) dropped exchange rate volatility, measured other variables differently, and used a different weighting specification. Three-stage least squares (3SLS) was used to control for endogeneity of the mark-up rate, which was interacted with the exchange rate.

[8] The signs of the exchange rate effects were reversed in this paper because the exchange rate was defined as the home currency price of foreign exchange. In the following discussion, the reported results are translated into the equivalent effects of changes in the value of the dollar.

[9] Campa & Goldberg (1999) included a measure of the total import share of domestic consumption in their equation for the mark-up rate, but not in their investment equation.

[10] Campa & Goldberg (1999) also applied the Beveridge & Nelson (1981) filtering procedure to estimate the 'permanent' and 'transitory' components of exchange rate changes and used only the permanent component in their regression models. The authors did not report any sensitivity tests for how this procedure affected their results.

[11] The user cost of capital is designed to measure the theoretical rental cost of a unit of capital in a neoclassical production function (see Hall & Jorgenson, 1967). See below for the precise definition used in this paper and comparisons with other definitions in the literature.

[12] In this vein, Lavoie *et al.* (2004) compare neo-Marxian and neo-Kaleckian models of investment using aggregate Canadian time-series data. They focus on the dynamic adjustments of capital stock growth rates and capacity utilization rates to long-run 'normal' levels.

[13] This view originated in the heterodox tradition of Kalecki (1937), Steindl (1952) and Minsky (1986), but was also found in mainstream Keynesian investment models of the 1950s (e.g. Meyer &

Kuh, 1957); it was later revived in a neoclassical framework in models of credit rationing with asymmetric information (e.g. Stiglitz & Weiss, 1981). See Fazzari *et al*. (1988) for a survey.

[14] Many (although not all) of these studies assume that the effects of profits (especially when measured by cash flow) reflect financial or liquidity constraints based on asymmetric information. Chirinko & Schaller (1995, p. 529) find evidence in support of this view in their study of Canadian firm-level data, in which the firms that have greater 'difficulty in communicating private information to outsiders' also face stronger liquidity constraints.

[15] Crotty and Goldstein (1992) included a foreign relative cost variable in their theoretical model, but then used the import penetration ratio as a proxy in their empirical work.

[16] Some of Campa & Goldberg's trade-weighted exchange rate measures were interacted with the price-cost margin (in their 1995 article) or profit mark-up rate (in their 1999 article), for reasons implied by their theoretical models, but these profit variables were not included as separate regressors in their investment equations.

[17] This effect is greater, the greater are the 'Marshall-Lerner' elasticities of demand for exports and imports, although strictly speaking the Marshall-Lerner *condition* for a devaluation to improve the trade balance is not relevant to the effect on investment *per se*.

[18] The traditional literature on investment functions effectively imposes the restriction that all the β_{4i} coefficients in equation (1) are zero. The literature on the effects of exchange rates on investment can be viewed as imposing the restriction that the β_{5i} coefficients are all zero. If any of these restrictions is incorrect, then the restricted estimates of the investment function could be biased.

[19] Chirinko & Schaller (1995) and Chirinko *et al.* (1999) emphasize that variables that affect the desired capital stock should enter the investment function in differences (or percentage changes) for this reason, whereas variables that reflect short-run financial constraints should enter the investment function in levels. By this logic, if either the exchange rate, cash flow ratio, or net profit rate affects the desired capital stock, that variable should be expressed in difference form, whereas if it affects financial constraints it should be expressed in levels.

[20] A disadvantage of this approach is that it imposes the same long-run dynamics for all the independent variables, a restriction which is not found to be true in studies that allow different lag lengths for different variables. For example, Chirinko *et al*. (1999) have up to six annual lags on some variables, and four lags on most. However, most of these studies gain extra degrees of freedom by using either firm- or industry-level panel data.

[21] Quarterly data for investment, capital stock, depreciation and profits in US manufacturing are not available for recent years anyway. The quarterly data series for industry-level investment used by Goldberg (1993) are no longer produced.

[22] More detailed definitions and sources for all variables are given in the appendix, below.

[23] The series were spliced by multiplying the ratio of the NAICS measures for 1999 to 1998 times the SIC-based measure for 1998 to obtain the value for 1999, and then applying the annual percentage changes in the NAICS series to the lagged spliced series to create data for 2000-2004. Although the levels of net profits and cash flow were quite different in the two data sets (for the overlapping years), the ratios of these variables to the lagged capital stocks were much more

similar, thus giving us greater confidence in the spliced measures created using the ratios.

[24] The SIC-based estimates are not reported here, but are available from the author on request.

[25] Standard definitions of *UC* also make adjustments for the tax treatment of investment, but we omit tax policy variables because our focus is on exchange rates rather than fiscal policy. In Chirinko *et al.* (1999, p. 57), the entire expression on the right-hand side of our equation (4) is multiplied by the ratio $(1 - x_t - z_t)/(1 - \tau_t)$, where x is the investment tax credit, z is the discounted value of depreciation allowances for tax purposes, and τ is the tax rate.

[26] Details on the unit root tests along with descriptive statistics, correlation coefficients and Granger-causality tests are presented in an unpublished statistical appendix, which is available from the author on request.

[27] This statement includes the percentage change the user cost, which is the variable actually included in the estimated investment functions, although stationarity is rejected at the 5% level for the user cost measured in levels according to this test.

[28] Note that this procedure may result in the inclusion of some variables that appear insignificant according to more conventional *t*-tests or *F*-tests.

[29] The Durbin-Watson (DW) test is not valid with a lagged dependent variable and hence is not reported in Tables 1-3. The Breusch-Godfrey Lagrange Multiplier (LM) test (Godfrey, 1988) is used instead because it is valid with a lagged dependent variable and also allows us to test the null hypothesis of no serial correlation for any number of lagged residuals.

[30] The first difference of the real interest rate was used partly for empirical reasons (using the level instead of the change produced an insignificant coefficient), partly for theoretical reasons (because the investment function literature implies that the cost-of-capital variable should enter in rate of change form) and partly for consistency with some of the previous literature on exchange rate effects (especially Campa & Goldberg, 1999).

[31] However, the Breusch-Godfrey LM test with two lags has a *p*-value of 0.091 in equation (1.3). This suggests serial correlation of the residuals, which would invalidate hypothesis tests using this equation.

[32] We cannot reject the null hypothesis that the net profit rate (in levels) has a unit root using an ADF test with either an intercept only or an intercept plus a trend; only the first difference of the net profit rate is stationary according to this test. ADF tests also show that the cash flow ratio has a unit root in levels with an intercept only, although the null of a unit root can be rejected at the 5% level with an intercept and a trend. The alternative test due to Kwiatkoswki *et al.* (1992) shows that the cash flow ratio is stationary in levels with an intercept alone, while the results for the net profit rate are sensitive to whether a trend is included and the significance level used.

[33] The current real dollar index was not significant in these equations and hence was omitted.

[34] The current-year changes in user cost, net profits and cash flow were insignificant (according to *t*-tests) and redundant (according to LR tests) and hence were omitted.

[35] As noted by Chirinko *et al.* (1999, p. 61), with investment measured relative to the lagged capital stock and the user cost expressed as a percentage change, the elasticity of the long-run desired

capital stock with respect to the user cost is the sum of the coefficients on the distributed lags of $\Delta UC_{t-i}/UC_{t-i-1}$. In the present model, although there is only one lag of this variable (i = 1), the long-run coefficient can be calculated from equation (2) with $m = 3$ and $\beta_{30} = 0$.

[36] As a sensitivity test, we also tried equations similar to those shown in Tables 1-3 with the real dollar index measured in first differences; the differenced real dollar index (either current or lagged) was not significant in any of these regressions. Following the logic of Chirinko & Schaller (1995) and Chirinko *et al.* (1999), the fact that the real dollar index is significant in levels rather than in differences suggests that its effects are short-run rather than long-run.

[37] These difficulties with the profit equation are not surprising, since the only variable that was significant at the 5% level in Clarida's model of US manufacturing profits was the exchange rate (Clarida, 1997, p. 182).

[38] Clarida (1997) uses demand for domestic goods instead of GDP because the former excludes exports. We constructed the same measure and tested it in our profit equations, and found that it yielded very similar results to the GDP growth rate but with a slightly worse fit.

[39] Although the Breusch-Pagan LM tests thus show no significant correlation of the OLS residuals, as a sensitivity test we used 3SLS to estimate the same four pairs of equations for investment and profits shown in Table 5. All the exogenous and predetermined variables in the two equations were used as instruments. The coefficient estimates were very close to those found using OLS, confirming that there is negligible simultaneity bias in the OLS estimates.

[40] Since we simulate these two equations as a system, we use the 3SLS estimates discussed in the previous note rather than the OLS estimates shown in Tables 3 and 4, but this makes little difference to the results.

[41] The baseline simulation represents the dynamic forecast of the complete five-equation model based on the actual values of the exogenous variables (including the real dollar index) and the forecast lagged values of the endogenous variables. These simulations assume that the other exogenous variables would have remained the same even if the dollar had stayed lower. Actual real investment in 2004 was $165.8 billion.

[42] These are 'high end' forecasts of the effects of the appreciation of the dollar, because equation (3.4) has a relatively high estimated coefficient on the dollar and includes an indirect effect via lagged changes in the cash flow ratio. Using the investment equations with a lower exchange rate elasticity and no cash flow effect, the simulated effects are roughly half to two-thirds as large.

[43] Another difference is that the change in the real interest rate was generally insignificant using the current cost investment rate, although the percentage change in the user cost was significant. The coefficients on the lagged dependent variable were smaller (around 0.5 to 0.6) in the alternative estimates. The short-run coefficients on the real dollar index were slightly larger in absolute value (around −0.04 to −0.06), but the long-run coefficients (and elasticities) were smaller because of the smaller coefficient on the lagged dependent variable. The residuals were more problematic in these alternative estimates, requiring the use of outlier dummies in most specifications, most likely as a result of inflationary shocks.

References

Abel, A. B. & Blanchard, O. J. (1986) The present value of profits and cyclical movements in investment, *Econometrica*, 54(2), pp. 249-273.

Beveridge, S. & Nelson, C. (1981) A new approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the business cycle, *Journal of Monetary Economics*, 7, March, pp. 151-174.

Bhaskar, V. & Glyn, A. (1995) Investment and profitability: the evidence from the advanced capitalist countries, in G. A. Epstein & H. M. Gintis (Eds), *Macroeconomic Policy After the Conservative Era*, pp. 175-196 (Cambridge University Press).

Bosworth, B. P. (1993) *Saving and Investment in a Global Economy* (Washington: Brookings).

Breusch, T. & Pagan, A. (1980) The Lagrange Multiplier test and its application to model specification in economics, *Review of Economic Studies*, 47(1), pp. 239-253.

Campa, J. & Goldberg, L. S. (1995) Investment in manufacturing, exchange rates and external exposure, *Journal of International Economics*, 38(3/4), pp. 297-320.

Campa, J. M. & Goldberg, L. S. (1999) Investment, pass-through, and exchange rates: a cross-country comparison, *International Economic Review*, 40(2), pp. 287-314.

Chirinko, R. S. (1993) Business fixed investment spending: a critical survey of modeling strategies, empirical results, and policy implications, *Journal of Economic Literature*, 31(4), pp. 1875-1911.

Chirinko, R. S., Fazzari, S. M. & Meyer, A. P. (1999) How responsive is business capital formation to its user cost? an exploration with micro data, *Journal of Public Economics*, 74, pp. 53-80.

Chirinko, R. S. & Schaller, H. (1995) Why does liquidity matter in investment equations? *Journal of Money, Credit and Banking*, 27(2), pp. 527-548.

Clarida, R. (1997) The real exchange rate and US manufacturing profits: a theoretical framework with some empirical support, *International Journal of Finance and Economics*, 2(3), pp. 177-187.

Crotty, J. R. & Goldstein, J. P. (1992) A Marxian-Keynesian theory of investment demand: empirical evidence, in F. Moseley & E. N. Wolff (Eds), *International Perspectives on Profitability and Accumulation*, pp. 197-234 (Aldershot: Edward Elgar).

Fazzari, S. M. (1993) Monetary policy, financial structure, and investment, in G. A. Dymski, G. Epstein, & R. Pollin (Eds), *Transforming the U.S. Financial System: Equity and Efficiency for the 21st Century*, pp. 35-63 (Armonk, NY: M.E. Sharpe).

Fazzari, S. M., Hubbard, R. G. & Petersen, B. C. (1988) Financing constraints and corporate investment, *Brookings Papers on Economic Activity*, (1), pp. 141-206.

Feinberg, R. M. (1986) The interaction of market power and exchange rate effects on German domestic prices, *Journal of Industrial Economics*, 35(1), pp. 61-70.

Feinberg, R. M. (1989) The effects of foreign exchange movements on United States domestic prices, *Review of Economics and Statistics*, 71, pp. 505-511.

Godfrey, L. G. (1988) *Specification tests in econometrics* (Cambridge: Cambridge University Press).

Goldberg, L. S. (1993) Exchange rates and investment in United States industry, *Review of Economics and Statistics*, 75(4), pp. 575-588.

Gordon, D. M. (1995) Putting the horse (back) before the cart: disentangling the macro relationship between investment and saving, in G. A. Epstein & H. M. Gintis (Eds), *Macroeconomic Policy After the Conservative Era*, pp. 57-108 (Cambridge: Cambridge University Press).

Gordon, D. M. (1997) Must we save our way out of stagnation? the investment-saving relationship revisited, in R. Pollin (Ed.), *The Macroeconomics of Saving, Investment, and Finance*, pp. 95-171 (Ann Arbor: University of Michigan Press).

Greene, W. H. (1997) *Econometric Analysis*, 3rd edn (Upper Saddle River: Prentice-Hall).

Hall, R. E. & Jorgenson, D. W. (1967) Tax policy and investment behavior, *American Economic Review*, 57(3), pp. 391-414.

Hendry, D. F. & Krolzig, H. (2002) *Automatic Econometric Model Selection Using PcGets 1.0* (London: Timberlake Consultants).

Kalecki, M. (1937) The principle of increasing risk, *Economica*, 4, November, pp. 440-447.

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P. & Shin, Y. (1992) Testing the null hypothesis of stationary against the alternative of a unit root, *Journal of Econometrics*, 54, pp. 159-178.

Lavoie, M., Rodriguez, G. & Seccareccia, M. (2004) Similitudes and discrepancies in post-Keynesian and Marxist theories of investment: a theoretical and empirical investigation, *International Review of Applied Economics*, 18(2), pp. 127-149.

Marglin, S. A. (1984) *Growth, Distribution, and Prices* (Cambridge: Harvard University Press).

Marston, R. C. (1990) Pricing to market in Japanese manufacturing, *Journal of International Economics*, 29, pp. 217-236.

Meyer, J. R. & Kuh, E. (1957) *The Investment Decision: An Empirical Stud*y (Cambridge: Harvard University Press).

Minsky, H. (1986) *Stabilizing an Unstable Economy* (New Haven: Yale University Press).

Newey, W. & West, K. D. (1987) A simple positive semi-definite heteroskedasticity and autocorrelation consistent covariance matrix, *Econometrica*, 55, pp. 703-708.

Robinson, J. (1962) *Essays in the Theory of Economic Growth* (London: Macmillan).

Steindl, J. (1952) *Maturity and Stagnation in American Capitalism* (Oxford: Blackwell).

Stiglitz, J. E. & Weiss, A. (1981) Credit rationing in markets with imperfect information, *American Economic Review*, 71(3), pp. 393-410.

Stockhammer, E. (2004) *The Rise of Unemployment in Europe: A Keynesian Approach* (Cheltenham: Edward Elgar).

US Census Bureau (2005) U.S. international trade in goods and services: annual revision for 2004, release of 10 June, www.bea.gov/bea/newsrelarchive/2005/trad1305.pdf.

US Congress, Joint Economic Committee (2006), *Economic Indicators*, March 2006 (Washington: Government Printing Office).

Worthington, P. R. (1991) Investment, GNP, and real exchange rates, *Economic Perspectives* (Federal Reserve Bank of Chicago), 15(4), pp. 2-10.

Worthington, P. R. (1995) Investment, cash flow, and sunk costs, *Journal of Industrial Economic*s, 43(1), pp. 49-61.

Appendix

Data definitions and sources

The following series are annual aggregates for the US manufacturing sector (NAICS definition), expressed in billions of chained 2000 dollars, from US Department of Commerce, Bureau of Economic Analysis (BEA), Fixed Asset Tables, revised 15 March 2006, www.bea.gov/bea/dn/home/fixedassets.htm (except as noted):

Investment: Chain-type quantity index (2000 = 100) for investment in private fixed assets (Table 3.8ES) multiplied by the 2000 value of historical-cost investment in private fixed assets (Table 3.7ES).

Capital stock: Chain-type quantity index (2000 = 100) for net stock of private fixed assets (Table 3.2ES) multiplied by the 2000 value of current-cost net stock of private fixed assets (Table 3.1ES); except, for calculating the net profit rate and cash flow ratio using SIC-based data up to 1999, we used the same variables from the old SIC-based Fixed Asset Tables (indexes based on 1996 = 100), www.bea.gov/bea/dn/FAweb/Index2002.htm.

Depreciation: Chain-type quantity index (2000 = 100) for depreciation (Table 3.5ES) multiplied by the 2000 value of current-cost depreciation (Table 3.4ES).

Chain-type price indexes for investment and capital stock: calculated by the ratio of the current-cost series to the real series (in chained 2000 dollars) for each variable.

The following series (annual data in billions of current dollars for the aggregate manufacturing sector) were obtained from BEA, National Income and Product Account (NIPA) tables, www.bea.gov/bea/dn/home/gdp.htm (tables ending in ‘B’ and ‘C’ define manufacturing on an SIC basis up to 2000; tables ending in ‘D’ define it on a NAICS basis from 1998 forward):

Net profits: Corporate profits (Tables 6.16B-D).

Cash flow: Sum of undistributed corporate profits (Tables 6.21B-D) plus corporate capital consumption allowances (Tables 6.22B-D).

The following series are for the aggregate US economy from the sources indicated:

GDP growth rate: Annual percent change from preceding period in real gross domestic product, BEA, NIPA Table 1.1.1.

C*hain-type price index for GDP*: Price index for gross domestic product, BEA, NIPA Table 1.1.4 (index, 2000 = 100) or Table 1.1.7 (annual percentage change).

Real dollar index: Real, broad index of the value of the US dollar, March 1973 = 100; Federal Reserve Board, Statistical Release H.10, Foreign exchange rates, summary measures of the foreign exchange value of the dollar, www.federalreserve.gov/releases/h10/summary/, monthly data converted to annual averages.

Aaa bond interest rate: Average annual yield for Moody's Aaa corporate bonds, *Economic Report of the President 2006* (ERP), www.gpoaccess.gov/eop/download.html, Statistical Table B-73.

Dividend-price ratio: Average annual dividend-price ratio for S&P common stock, ERP, Statistical Tables B-95 and B-96.

Table 1. Investment functions with the real interest rate and exchange rate, with and without alternative profit variables (sample period 1974-2004, 31 annual observations)

Dependent variable: Investment rate (t)					
Equation:	(1.1)	(1.2)	(1.3)	(1.4)	(1.5)
Constant	5.276***	6.037***	5.176***	4.302***	4.294***
	(0.968)	(1.194)	(1.386)	(1.048)	(1.182)
Investment rate (t-1)	0.774***	0.778***	0.793***	0.812***	0.826***
	(0.057)	(0.068)	(0.071)	(0.066)	(0.065)
GDP growth rate (sum of t and t-1)	0.298***	0.314***	0.240***	0.216**	0.202***
	(0.064)	(0.064)	(0.058)	(0.078)	(0.069)
ΔReal Aaa interest rate (sum of t and t-1)	-0.352***	-0.312**	-0.404***	-0.349**	-0.353**
	(0.119)	(0.140)	(0.105)	(0.125)	(0.143)
Real dollar index (sum of t and t-1)	-0.042***	-0.047***	-0.039***	-0.032***	-0.033***
	(0.011)	(0.010)	(0.009)	(0.009)	(0.010)
Net profit rate (sum of t and t-1)[a]		-0.030		0.130	
		(0.029)		(0.091)	
Cash flow ratio (sum of t and t-1)[a]			-0.009		0.207*
			(0.037)		(0.115)
Adjusted R^2	0.874	0.870	0.883	0.878	0.893
SE	0.530	0.537	0.511	0.522	0.488
SSR	6.451	6.063	5.486	5.716	4.992
Diagnostic tests:[b]					
Breusch-Godfrey LM tests					
1 lag	0.580	0.783	0.951	0.587	0.800
2 lags	0.329	0.269	0.091*	0.185	0.040**
RESET	0.186	0.378	0.314	0.405	0.572
Jarque-Bera Normality	0.598	0.751	0.927	0.872	0.795

Notes: Estimation is by OLS. Numbers in parentheses are Newey-West adjusted standard errors.

Significance levels: *10%, **5%, ***1%.

[a]Measured in levels in equations (1.2) and (1.3) and in first differences (Δ) in equations (1.4) and (1.5).

[b]Numbers shown are *p*-values for all tests. RESET is the test for squared fitted values.

Table 2. Investment functions with the user cost of capital and profit variables, with and without the exchange rate (sample period 1974-2004, 31 annual observations)

Dependent variable: Investment rate (t)				
Equation:	(2.1)	(2.2)	(2.3)	(2.4)
Constant	-0.310	-1.422	5.687***	4.660***
	(0.796)	(1.488)	(1.274)	(1.434)
Investment rate (t-1)	0.878***	0.912***	0.810***	0.830***
	(0.068)	(0.091)	(0.049)	(0.053)
GDP growth rate (sum of t and t-1)	0.178**	0.177***	0.292***	0.261***
	(0.068)	(0.060)	(0.063)	(0.060)
Δ User cost (t-1)/user cost (t-2)	-0.067**	-0.052*	-0.059*	-0.065**
	(0.026)	(0.030)	(0.031)	(0.028)
Real dollar index (t-1)			-0.049***	-0.045***
			(0.011)	(0.008)
Net profit rate (t)	0.083**		-0.007	
	(0.033)		(0.031)	
Cash flow ratio (t)		0.104**		0.028
		(0.049)		(0.049)
Adjusted R^2	0.830	0.817	0.883	0.884
SE	0.616	0.639	0.511	0.507
SSR	9.487	10.207	6.255	6.181
Diagnostic tests:[a]				
Breusch-Godfrey LM tests				
1 lag	0.107	0.029**	0.672	0.681
2 lags	0.273	0.087*	0.484	0.535
RESET	0.570	0.265	0.593	0.439
Jarque-Bera Normality	0.846	0.881	0.592	0.674
Omitted variable LR test for:				
Real dollar index (t-1)	0.0003***	0.0001***		

Notes: Estimation is by OLS. Numbers in parentheses are Newey-West adjusted standard errors.
Significance levels: *10%, **5%, ***1%.

[a]Numbers shown are *p*-values for all tests. RESET is the test for squared fitted values.

Table 3. Investment functions with the user cost of capital and differenced profit variables, with and without the exchange rate (sample period 1974-2004, 31 annual observations)

Dependent variable: Investment rate (t)				
Equation:	(3.1)	(3.2)	(3.3)	(3.4)
Constant	0.682	0.575	4.719***	5.235***
	(0.536)	(0.668)	(0.781)	(0.665)
Investment rate (t-1)	0.909***	0.877***	0.843***	0.830***
	(0.054)	(0.077)	(0.052)	(0.045)
GDP growth rate (sum of t and t-1)[a]	0.076	0.192***	0.203***	0.227***
	(0.064)	(0.065)	(0.065)	(0.049)
Δ User cost (t-1)/user cost (t-2)	-0.051**	-0.050**	-0.064***	-0.074***
	(0.024)	(0.021)	(0.022)	(0.020)
Real dollar index (t-1)			-0.040***	-0.045***
			(0.007)	(0.005)
Δ Net profit rate (t-1)	0.197***		0.093	
	(0.058)		(0.057)	
Δ Cash flow ratio (t-1)		0.139*		0.114***
		(0.069)		(0.040)
Adjusted R^2	0.847	0.823	0.895	0.904
SE	0.584	0.628	0.483	0.462
SSR	8.858	9.851	5.603	5.129
Diagnostic tests:[b]				
Breusch-Godfrey LM tests				
1 lag	0.804	0.195	0.603	0.315
2 lags	0.966	0.193	0.515	0.481
RESET	0.980	0.749	0.844	0.573
Jarque-Bera Normality	0.900	0.854	0.798	0.906
Omitted variable LR test for:				
Real dollar index (t-1)	0.001***	0.0001***		

Notes: Estimation is by OLS. Numbers in parentheses are Newey-West adjusted standard errors.

Significance levels: *10%, **5%, ***1%.

[a]Except for equation (3.1), in which the lag (t-1) was redundant by an LR test and only current (t) was included.

[b]Numbers shown are *p*-values for all tests. RESET is the test for squared fitted values.

Table 4. Alternative estimated equations for the net profit rate and cash flow ratio

Dependent variable:	Net profit rate (t)		Cash flow ratio (t)	
Equation:	(4.1)[a]	(4.2)[b]	(4.3)[c]	(4.4)[d]
Specification:	Levels	Differences	Levels	Differences
Sample period:	1974-2004	1975-2004	1974-2004	1975-2004
Constant	12.865***	-0.115	18.405***	0.222
	(2.902)	(0.252)	(5.359)	(0.222)
Net profit rate (t-1)	0.580***			
	(0.066)			
Cash flow ratio (t-1)			0.215	
			(0.173)	
GDP growth rate (sum of t and t-1)	0.706***	0.720***	0.816***	0.648***
	(0.062)	(0.150)	(0.104)	(0.120)
Real dollar index[e]	-0.097***	-0.160***	-0.063**	-0.135**
	(0.022)	(0.028)	(0.025)	(0.055)
Time trend (t)	-0.071**		-0.128***	
	(0.027)		(0.038)	
Observations	31	30	31	30
Adjusted R^2	0.943	0.673	0.790	0.743
SE	0.911	1.277	1.190	1.099
SSR	19.087	40.737	33.977	26.552
Diagnostic tests:[f]				
Durbin-Watson		2.016		2.225
Breusch-Godfrey LM tests				
1 lag	0.324	0.767	0.651	0.492
2 lags	0.554	0.952	0.813	0.764
RESET	0.412	0.300	0.835	0.047**
Jarque-Bera Normality	0.360	0.613	0.570	0.761

Notes: Estimation is by OLS. Numbers in parentheses are Newey-West adjusted standard errors.
In the "differences" regressions, all variables are first differenced except the outlier dummies.
Significance levels: *10%, **5%, ***1%.

[a]Also includes outlier dummies for 1975, 1986 and 2001, not shown separately; GDP growth (t-1) was redundant and insignificant and was omitted from this equation.

[b]Also includes an outlier dummy for 2001, not shown separately.

[c]Also includes an outlier dummy for 1974, not shown separately.

[d]Also includes outlier dummies for 1975, 1986, 1989 and 2001, not shown separately.

[e]Based on redundant variable LR tests as well as *t*-tests, only the current value (t) was included in equations (3.1) and (3.4), while only the lagged value (t-1) was included in (3.2) and (3.3).

[f]Numbers shown are *p*-values for all tests except the Durbin-Watson statistic, which is reported only for equations with no lagged dependent variable. RESET is the test for squared fitted values.

Table 5. Breusch-Pagan tests for cross-equation correlation of OLS residuals

Equations (investment, profits)[a]	(2.3, 4.1)	(2.4, 4.3)	(3.3, 4.2)	(3.4, 4.4)
Specification of profits	Net profit rate, Levels	Cash flow ratio, Levels	Net profit rate, Differences	Cash flow ratio, Differences
Residual correlation (ρ)	0.170	0.071	0.172	0.081
Observations (n)	31	31	30	30
λ (LM statistic)	0.899	0.158	0.888	0.197
p-value	0.343	0.691	0.346	0.657

Note: With 2 equations, the LM statistic is $\lambda = n\rho^2 \sim \chi^2(1)$ under the null hypothesis of no correlation. All numbers are independently rounded.

[a]Equation numbers refer to columns of regression results in tables 2, 3 and 4.

Figure 1. Dynamic simulations of real investment: scenario with no dollar appreciation after 1995 versus model baseline